ELECTROSTATIC DISSIPATING GARMENTS AND FABRICS FOR USE IN MAKING SAME

TECHNICAL FIELD

The present invention relates generally to electrostatic dissipating fabrics and more particularly to electrostatic dissipating fabrics incorporating spun yarns which include conductive staple fiber constituents incorporated within the spun yarns.

BACKGROUND

It is well known that when clothing fabric is used in environments such as a clean room or other areas where humidity is reduced or controlled, such fabrics may be susceptible to an accumulation of static electricity. This accumulation in static electricity may be particularly pronounced as humidity is reduced due to the fact that the static electricity cannot dissipate into the air. As will be well recognized, under extreme circumstances an accumulation in static electricity may give rise to a rapid electric discharge in the form of an arc when the fabric is brought into contact with a grounded structure.

In recent years so-called “solid state” electronic circuitry using integrated circuits on semi-conductor materials such as silicon, and the like has moved towards ever finer circuit arrangements. While such technology and the resulting electronic components are extremely useful in carrying out a range of functions with very small space requirements, the decreased circuit

geometries within those structures has made the electronic components highly susceptible to damage from external electric charges. In order to avoid the potential for damage which may result from the rapid discharge of static electricity, it is desirable to avoid the accumulation of static electricity within garments and other textile structures used within an electronics manufacturing environment.

In order to facilitate the dissipation of static electricity away from a garment and into the atmosphere, it is desirable to distribute any electric charge substantially across the garment thereby providing the highest possible surface area for atmospheric dissipation. The substantial conduction of electric charge throughout the garment also permits the effective use of grounding wires in the form of bracelet-like structures attached to grounded cords which may be worn by the user of the garment.

Garments such a lab coats and the like which may be worn during the assembly of electronic components are normally formed by the seamed attachment of fabric panels. If the electrical resistance between segments of the garment is too high, the possibility may exist for segments of the garment to become conductively isolated. If these conductively isolated segments of the garment cannot dissipate the built up static electricity and/or are not directly connected to a grounding source, potentially undesirable and uncontrolled rapid discharge of static electricity may occur on a periodic basis. As indicated above, the magnitude of such a discharge need not be

substantial in order to be potentially damaging to sophisticated electronic circuitry.

In order to address these issues, a number of fabric constructions and materials have been previously proposed. By way of example only, various arrangements are proposed in the following U.S. patents each of which is incorporated herein by reference in its entirety. In U.S. patent 2,845,962 an anti-static fabric is disclosed which is made from a fibrous material containing electrically conductive carbon black. U.S. patent 3,288,175 teaches the incorporation of a small quantity of metallic fibers within the textile fiber materials to produce an anti-static fabric. U.S. patent 3,586,597 discloses the use of a fiber which is coated with a resinous matrix of finely divided silver or carbon black. U.S. patent 4,255,487 discloses an electrically conductive textile fiber in which electrically conductive particles are suffused into a filamentary polymer substrate in an annular region located at the periphery of the filamentary polymer substrate. U.S. patent 4,869,951 discloses a static dissipating textile incorporating non-linear carbonaceous fibers or filaments. Currently, fabric dissipating fabric for use in clothing articles in electronic manufacturing environments generally uses an arrangement of substantially non-conductive yarns in combination with conductive filament yarns. By way of example only, and not limitation, various constructions incorporating such conductive filament yarns are described in U.S. patents 4,557,968 and 4,606,968.

In the past, it has been found that garments such as lab coats and the like formed from prior electrostatic dissipating fabrics have been susceptible to an overall reduction in conductivity following multiple uses and washings. In particular, it has been found that the sleeve to sleeve conductivity measured between the cuff portions of sleeves on such garments may dramatically degrade due to the naturally occurring seam combing or separation which occurs between the panels of fabric forming the garment at the shoulder seams connecting the sleeves to the body of the garment. That is, after multiple washings the seams between the sleeves and the body portion of the garment may tend to undergo a very slight separation. Due to the relatively dispersed nature of the conductive filament yarns in the fabric forming the panels of material, this separation may give rise to a substantial reduction in conductivity across the seam. Thus, electrostatic charges may be prevented from efficiently traveling across the seam junction between the sleeves and the body portion of the garment. This reduction in conductivity may give rise to the potentially undesirable buildup of static electricity within portions of the garment.

SUMMARY

The present invention provides advantages and alternatives over the prior art by providing electrostatic dissipating fabrics incorporating spun yarns which include conductive staple fiber constituents incorporated within the spun yarns in conjunction with a grid of conductive filament yarns. The fabrics may be of either a woven or knit construction and are particularly adapted for use

in garments worn during the construction of electronic components where arcing from accumulated static electricity is to be avoided. The conductive fiber constituents are dispersed at an effective concentration to establish a network of charge carrying junctions within and between the individual yarns. The large number of junctions between the yarns facilitates the dissipation of static electricity between regions of a garment formed by the yarns. In particular, the fabric retains a high degree of conductivity across seams within the garment even after multiple washings.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described by way of example only, with reference to the accompanying drawings which constitute a part of the specification herein and in which:

FIG. 1 is a schematic illustration of a lab coat as may be worn in an electronics manufacturing environment;

FIG. 2 is an exemplary woven fabric construction incorporating a grid arrangement of conductive filament yarns in combination with spun yarns;

FIG. 3 illustrates a section of spun yarn incorporating filamentary staple elements of electrically conductive character;

FIG. 4 is a plan view of the interface between two panels of woven fabric formed using the yarn of FIG. 3;

FIG. 5 is a plan view of an exemplary knit fabric construction as may be formed using the yarn of FIG.3; and

FIG. 6 is a plan view of the interface of two panels of woven fabric according to the invention showing the blended yarn in combination with a grid of conductive filament yarns.

While the invention has been illustrated and generally described above and will hereinafter be described in connection with certain potentially preferred embodiments, procedures and practices, it is to be understood that in no event is the invention to be limited to such illustrated and described embodiments, procedures and practices. On the contrary, it is intended that the present invention shall extend to all alternatives and modifications as may embrace the principles of this invention within the true spirit and scope thereof.

DESCRIPTION OF PREFERRED EMBODIMENTS

Reference will now be made to the drawings wherein, to the extent possible, like elements are designated by like reference numerals throughout the various views. Turning to the drawings, in FIG. 1, a jacket or lab coat 10 as may be utilized in an electronics manufacturing environment is illustrated. As shown, the lab coat 10 includes a main body portion 12 adapted to cover the torso of a user and two sleeve portions 14 extending away from the body

portion 12 to provide coverage across the arms of a user. As illustrated, the sleeves 14 are adjoined to the body portion 12 along seams 16 such as sewn seams or the like. As will be appreciated, additional seams may be disposed in adjoining relation between the front of the lab coat 10 and the rear of the lab coat 10 in a manner as will be well know to those of skill in the art.

Regardless of the actual construction of the lab coat 10, the individual portions thereof are preferably formed from panels of woven or knitted fabric which are sewn into a desired configuration. Thus, at the seams 16 as well as at other seams within the garment 10 discrete panels of fabric are joined together in slightly overlapping relation to one another. In a sewn seam construction, this adjoined relation is established and maintained by passing a stitching yarn 18 repetitively across the interface between the two panels of fabric at the interface of such panels of fabric.

In accordance with the present invention, the construction of the panels of fabric forming the segments of the garment 10 is preferably such that a controlled degree of electrical conductivity is established and maintained throughout the garment 10. One exemplary prior art fabric construction for use in the formation of the garment 10 is illustrated schematically in FIG. 2. As shown, in this prior art construction, a multiplicity of conductive filaments of material such as graphite or the like are interwoven in a substantially disperse grid-like arrangement with a multiplicity of multi-filament spun yarns 22. As will be appreciated, in the illustrated prior art construction, the conductive

circuit through the fabric is established by the junctions formed at the crossing points 24 between the conductive filament yarns 20. As shown, such crossing points 24 are dispersed relatively infrequently throughout the fabric construction. Moreover, in the event that two panels of such material are seamed together, the electrical connection between the two seamed panels is dependent upon the bridging contact between the conductive filament yarns 20 in each of the panels. Since such conductive filament yarns 20 are dispersed sparingly through the overall fabric, a disconnection of even a small number of the junctions established across the seam such as during washing or use will negatively impact the ability to efficiently conduct electricity across a seam structure. While this deficiency may be addressed by increasing the number of conductive filament yarns 20, such an increase may reduce the comfort of the fabric while substantially increasing manufacturing costs.

In order to promote the efficient distribution of electric charges throughout the garment 10, the present invention utilizes a fabric formed from a conductive spun yarn 40 which is formed into a conductive fabric 50. The fabric may be of either a woven construction (FIG. 4) or may be of a knit construction (FIG.5).

As illustrated, the conductive spun yarn 40 incorporates discrete conductive staple fibers 52 which are spun into the yarn in combination with staple fibers of substantially nonconductive polymeric or natural material such as (but not limited to) polyester, nylon, cotton, and mixtures thereof. As will

be appreciated by those of skill in the art, by the term “staple fiber” is meant any discrete length fiber which may be formed by known spinning techniques such as ring spinning, open end spinning or air jet spinning into a coordinated yarn structure. By way of example only, and not limitation, it is contemplated that the conductive staple fibers 52 are preferably formed from a substantially electrically conductive carbonaceous material such as graphite or graphite suffused fibers of substantially linear geometry having staple lengths in the range of about 1 mm to about 150 mm. However, it is contemplated that other staple fibers of electrically conductive character may likewise be utilized including relatively short lengths of natural or synthetic fibers rendered conductive by the deposition of a conductive polymeric material such as polypyrole, polyaniline, or other conductive polymers as described in U.S. Patent 4,803,096 to Kuhn et al. the teachings of which are incorporated by reference. It is also contemplated that the conductive staple fibers 52 may be formed from natural or synthetic fibers rendered conductive by deposition of a metallic material such as silver or copper sulfide.

Regardless of the actual construction and composition of the conductive staple fibers 52, such conductive staple fibers 52 are preferably dispersed throughout the conductive spun yarn 40 in a manner so as to render the conductive spun yarn 40 suitable for transmitting an electric charge therethrough and across seams formed between panels of the fabric. In this regard, the electrical conductivity of the garment 10, when made from the fabric 70 illustrated in FIG. 6, may be measured by standardized electrostatic

dissipation (ESD) tests such as the ESD Association's Test Method STM 2.1-1997. In such a test, leads are clipped between the sleeves 14 and a 10 volt charge is applied between the leads. The resistance between the leads is then measured. This test is carried out at a controlled relative humidity of 12%. In such a test, the measured sleeve to sleeve resistance is preferably less than 10^{12} Ohms and is more preferably in the range of 10^4 to about 10^{12} Ohms. It is most preferably in the range of about 10^4 to about 10^8 Ohms. While such tests provide useful standards for evaluation of conductivity in an overall garment, the fabric making up such garments may also be the subject of evaluation independent of the garment so as to discount the effects of factors such as garment size, numbers of seams and the like. One recognized test method for measuring electrical resistivity in a fabric is set forth at AATCC Test Method 76-1987 (incorporated by reference). According to this method, resistivity is reported in units of ohms per square based upon the following formula:

$$\frac{\text{Measured Resistance (ohms) X Width of Specimen}}{\text{Distance Between Electrodes}}$$

When measured according to this test procedure at 20% relative humidity using a 2 inch X 2 inch specimen at a 100 volt potential and 1 inch electrode spacing, fabrics according to the present invention preferably have generally similar resistivity measurements in both the machine and cross-machine directions with such levels preferably being less than about 1,000,000,000

ohms per square and more preferably in the range of about 100,000 to 100,000,000 ohms per square. In some environments, resistivity levels substantially below about 100,000 ohms per square may be undesirable due to the garment becoming overly conductive.

In order to achieve the desired electrical resistance levels, it is contemplated that the conductive fiber content in the spun yarn 40 is preferably in the range of about 1% to about 5% by weight and will more preferably be in the range of about 1% to about 3% by weight with the remainder of the conductive spun yarn 40 being made up of substantially non-conductive polymeric or natural fibers. By way of example, and not limitation, one contemplated composition for the conductive yarn 40 is 63% polyester fiber, 35% cotton fiber, and 2% carbon suffused acrylic staple fibers. In one exemplary construction, such a yarn may be spun into a 26/1 yarn for use in the warp direction of the conductive fabric 50 and into a 16/1 construction for use in the filling direction of the conductive fabric 50.

As illustrated in FIG. 4, the utilization of the conductive spun yarn 40 in the conductive fabric 50 establishes a substantially conductive arrangement with electrical junctions being established both along the length of each of the conductive yarns 40 as well as at any point of contact between the conductive yarns 40. That is, an electrical connection is established at every crossing point between the warp yarns and the fill yarns as well as at every contact point along a seam line 54. Thus, unlike the prior art construction illustrated in

FIG. 2, wherein electrical junctions are established only sporadically throughout the fabric structure, in the contemplated conductive fabric 50, the number of connections is virtually unlimited thereby providing an improved conduction path for static electricity through the conductive fabric 50. Of course, it is to be understood that while the woven version of the conductive fabric 50 is illustrated as being in a so-called "plain weave" construction, other weave constructions as well as knit constructions (FIG. 5) and the like as will be well know to those of skill in the art may be likewise be utilized if desired.

FIG. 6 illustrates a particularly preferred fabric of the invention, shown at 70. This fabric includes blended yarns 60 of the variety described previously at 40, interspersed in the fabric with a grid of electrically conductive filaments 64. A juncture formed by a seam 66 between two panels of fabric is shown, illustrating how the spun yarns define a network of electrically conductive junctions along the length of the spun yarns, between the spun yarns at locations where the spun yarns meet, and between the conductive filament yarns 64.

The invention may be further understood by reference to the following non-limiting example.

EXAMPLE

A woven fabric was formed with a plain weave construction using 11 ends per inch of an open end spun warp yarn of 26/1 construction and 1 end per inch of 2/70/30 polyester plied with 22/1 carbon suffused nylon filament at

87% polyester and 13% carbon suffused nylon and 7 picks per inch of a 16/1 open end spun yarn and 1 pick per inch of a 2/70/30 polyester plied with 22/1 carbon suffused nylon filament at 87% polyester and 13% carbon suffused nylon in the filling. Both the spun yarns in the warp and filling contained 63% polyester fiber, 35% cotton fiber, and 2% carbon fiber. The polyester fiber was KoSa T121 1.2 denier per filament fiber with a staple length of 1.5 inches. The cotton fiber had an estimated staple length of 31/32 of inch. The carbon fiber was a carbon sufused acrylic having a 1.5 inch staple length and a filament linear density of 3 denier. One such acrylic material is believed to be available from Sterling Fibers having a place of business in Pace Florida, USA. The filament yarn was carbon suffused nylon of the variety available from Shakespeare in Columbia, S.C. The resultant yarns were thereafter woven on a standard rapier weaving machine in a construction of about 92 ends per inch by 48 picks per inch. A lab coat was thereafter constructed from panels of the resultant woven fabric with seams adjoined by traditional yarn stitching. The resulting garment was thereafter subjected to ESD Association Test Method STM 2.1-1997 at 10 volts and 12% relative humidity. The measured electrical resistance after a controlled number of washings is set forth at Table 1.

TABLE 1

No. of Washings	Sleeve to Sleeve Resistance (Ohms)
0	8.3 X 10 **5
10	3.65 x 10**5
25	4.9 x 10**5
50	7.5 x10**5
75	1.05 x 10**6
100	1.57 x10**6

Of course, it is contemplated that conductive filament materials other than carbon suffused acrylic may likewise be utilized. In particular, it is contemplated that low percentages of nylon as well as polyester and the like which have been rendered conductive may also be used. By way of example only, one such nylon fiber material is believed to be available from Shakespeare Fibers having a place of business in Columbia, South Carolina, USA. As previously indicated, electrical conductivity in any of the materials as may be used in the conductive staple fibers may be imparted by carbonaceous materials as well as by the use of electrically conductive polymers or metallic additions.

While the present invention has been illustrated and described in relation to certain potentially preferred embodiments, procedures, and practices, it is fully contemplated that modifications and variations to the present invention will no doubt occur to those of skill in the art upon reading the preceding description and/or through practice of the invention. It is therefore intended that the invention shall extend to all such modifications and variations which incorporate the board principles of the present invention within the full spirit and scope thereof.